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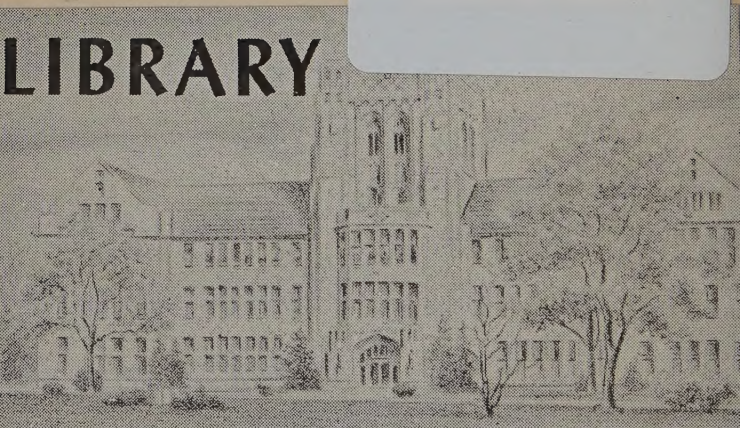

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A SHORT OUTLINE
of
COMPARATIVE PSYCHOLOGY

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A SHORT OUTLINE *of* COMPARATIVE PSYCHOLOGY

BY

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PREFACE

Perhaps the history of science—when it has been adequately written—will come to be the most interesting chapter in the history of mankind. For the story of science in its larger meaning is but the story of the long and unceasing attempt of man to interpret the world about him and to understand his own place in the natural order of things. No class of phenomena has excited greater interest or presented more knotty problems than that which we now include under the term comparative psychology—the mental life or behavior of organisms from the amœba to man. The present outline is a brief account of how the race has interpreted what it has known of animal life and behavior at various stages of development. To the general reader it is intended to supply the need for a broad, synthetic survey of fact and opinion in this field. To the more critical student, who may read it as the historical section of a forthcoming textbook, it should indicate in addition something of the struggle of comparative psychology to become a natural science.

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INTRODUCTION

THE rapid development of comparative psychology during the past three or four decades has doubtless tended to create the general impression that nothing worthy of the name had existed previously. It is true that only within this period has the science emerged as a separate discipline and established itself in a more or less clearly defined field, with its own systematic problems and experimental methodology. It is equally true, however, that comparative psychology, like most other branches of modern science, must seek for its humble beginnings in the remote past.

The larger aim and viewpoint of the modern movement cannot be justly appreciated or fairly evaluated apart from a knowledge of its more important historical antecedents. For it seems to be true that a science can no more outlive its tradition than an individual can outlive his heredity. And few modern disciplines possess a richer heritage of opinion and discussion than comparative psychology; few have been more consistently exploited in ages past by men of such diverse interest, temperament and training. The philosopher and the theologian as well as the naturalist, both trained and un-

trained, have each attempted to solve the riddle of the living organism and its behavior. In tracing the effect of these various influences upon the later development of the science, we shall find more often than not that facts have been either neglected or subordinated to theoretical bias; that in spite of the great variety of thinkers who have dealt with the problems that properly belong to this field, the general solutions offered have been few; that the more outstanding viewpoints of past epochs continue to be rallying points for various schools and "isms."

It is manifestly impossible, within the limited space here available, to present more than the briefest sketch in a historical survey that should properly extend back to the earliest beginnings of natural history. For, as we shall see, observations of animal behavior (typical overt activities in field and stream) were probably among the first to reach the scientific level, and may very conceivably have become the nucleus around which the zoölogical aspect of natural history finally developed. It is hoped that this brief sketch may serve, at any rate, to place the modern movement in a proper historical perspective, and afford a basis for the evaluation of present-day tendencies in this field.

A SHORT OUTLINE *of* COMPARATIVE PSYCHOLOGY

CHAPTER I

ANCIENT ANIMAL LORE

Early Origins.—A sketch of the development of comparative psychology might well begin with the writings of Aristotle which include, along with a mass of general natural history material, a fairly systematic account of the mental life of the animal world as he knew it. Certainly nothing of great importance for our topic, either in content or method, appears to have developed previous to the beginnings of science among the Greek philosophers of the sixth century B. C. Nevertheless, it has seemed appropriate to begin this survey with a brief account of the animal lore of the pre-scientific ages, including not only the great civilizations that antedate the rise of science among the Greeks but also the earlier prehistoric cultures as well.

It is a truism to say that the animal has played as important, and often a dominating rôle in the practical and cultural life of mankind from the earliest times. Contemporary animal life held a central place in the nature lore, magical rites and religious beliefs of prehistoric and later

peoples. This fact is illustrated in such fragments of ancient art as have been preserved to us, and in the mythological explanations of nature which appear as already time-worn traditions at the beginning of the historical era. The attitude of primitive man toward the animal world—and especially the close connection between animal lore and the religio-magical rites —during the thousands of years that elapsed before the birth of science, could not have been without significant influence upon the earliest scientific interpretations of animal life and behavior.

The fragmentary nature of prehistoric remains makes it impossible to reconstruct with any degree of definiteness or assurance the animal lore of this long period of "unwritten history." Such an attempt would involve too much of the purely speculative and would carry us too far afield. In scanning the long geologic period of mankind we come upon nothing of special interest concerning the topic at hand prior to the beginning of the Upper Paleolithic epoch (c. 25,000 B. C.—Osborn). About this time the Neanderthaler race in western and southern Europe was dispossessed by the Cro-Magnon, whose culture remained dominant until nearly the opening of Neolithic times. The Cro-Magnons show a development of animal art that appears striking indeed and seems to furnish a clue to the animal lore of their age and of the stage of primitive culture which they represent. It is among this people that we come

upon the earliest indications of extensive observation of animal behavior arising from what appears to be other than directly practical motives.

Upper Paleolithic Industry and Art.—The industrial deposits show clearly that the Cro-Magnon was nomadic and lived mainly by hunting and fishing. The hyena, cave-bear, and cave-lion were his mortal enemies; the bison, horse, deer and other wild animals and fishes were his daily food. A keen interest in the characteristic activities and mode of life of these animal forms would naturally be fostered by the direct, active struggle of man and animal to survive in a common environment. The superior powers and prowess of various animals forced the ancient cave man to resort to simple strategy in order to entrap and otherwise dominate them. The Paleolithic hunter and fisherman were, at their best, probably primitive naturalists, displaying deliberate and careful observation when circumstances demanded. Much of the information thus acquired doubtless entered into the verbal tradition of the times. A very considerable store of observations concerning the animal world, largely but not wholly practical in nature, must have accumulated in process of time.

The art of the Cro-Magnon, both mobile and parietal,[1] appears to have been autochthonous, and shows a gradual development from Early Aurig-

[1] Industrial or mobile art (l'art mobilier) consists of the decoration of small personal belongings, orna-

nacian to middle or late Magdalenian times, although the various forms of it (sculpture, engraving or etching, and painting) apparently reached their height at different times during this long epoch. It is significant for our purposes that the art of the Cro-Magnon deals almost exclusively with animal form and motion, neglecting for the most part not only the plant and inanimate worlds but even man himself. Surprisingly accurate, realistic representation of contemporary animal life distinguishes the art of this period from that of even much later times, and justifies the reference of Osborn to the Cro-Magnons as the Paleolithic Greeks. The mural paintings of the caverns represent their most noteworthy attempts to portray animal form and behavior. Among the best of these are the famous polychrome frescoes of Marsoulas, Font-de-Gaume, and Altamira.

Concerning the work of the Cro-Magnon artists, Locy says:

> An immense number of these pictures are known representing the mammoth, the horse, the reindeer, the red deer, the cave-bear, the cave-lion, hyena, bison, aurochs, grouse, ptarmigan, etc. They are by no means sporadic, but are distributed over a wide geographical area, indicating that there were many individuals who observed and sketched with varying degrees of skill. Bearing in mind that the purpose of the

ments, and implements of stone, bone, and ivory; mural or parietal art (l'art parietal) consists of drawings, engravings, paintings, and bas-reliefs on the walls of caverns and grottoes (Osborn).

pictures as well as the life and social condition of this remote people is conjectural, the great number of pictures suggest that there might have been a guild of picture makers (or artist-naturalists as Locy suggests in another connection) whose occupation passed on from generation to generation. The better class of pictures cannot be interpreted as the sudden inspiration of untutored savages; some of the best bear internal evidence of careful and prolonged observation. The artists were wonderful observers of limb motion and many drawings show exact proportions of head, body, limbs, horns, hoofs, etc.; others show posture, locomotion, fighting, herding, and migration.

The primary impulse behind this development of art, extending over many thousands of years, was probably neither scientific nor artistic in any modern sense, but occult; and on this assumption the pictures represent refinement in magic or religious ceremony. Some objects of mobilary art were evidently idols, fetiches, or likely were connected with totemism. Obermaier calls attention to the fact that the mural paintings and bas-reliefs are often found in relatively inaccessible recesses of caverns, and were thus apparently not meant for ordinary human observation. He believes these were used in connection with the magic of the chase, magic propitious to fertility of animals used for food, protective magic and the like. Mutilation of the representations of certain ferocious animals such as the cave-bear, tiger, etc., by weapons suggests that magic incantations were practiced

upon them. The animal as well as the human enemy was evidently made weak in effigy. Whatever the source of this widespread interest, it led to keen and accurate observation of animal behavior by primitive man thousands of years before the dawn of history.

Neolithic and Later Epochs.—Very little of special interest regarding the animal lore of the Neolithic, Bronze and Iron ages of European culture has been disclosed by the deposits so far recovered. The early stages of Neolithic culture give evidence of the domestication of the dog, horse, pig, and many other animals along with the beginnings of settled tribal life. In spite of the tremendous advance of Neolithic over Paleolithic man in most ways, his representation of animal life is on a distinctly lower level, taking the period as a whole. The drawings are usually more crude. They are marked, however, by the frequent appearance of composition, in which the human figure, usually more or less conventionalized, often appears. Hunting scenes which include the bow and arrow, or other weapon, and the now domesticated dog, are not unusual. Apparently Neolithic man was a less careful observer of animal form and behavior than his predecessor had been, or possessed less skill in the art of portrayal.

Of the later epochs, the Minoan culture, representing the Bronze age in the land of the ancient Greeks, offers the most striking examples of animal art, and suggests the existence of a rich animal lore. The famous Vaphio gold cups

(see Singer) illustrate the marvellous, realistic portrayal of animal form and movement during the late Minoan period (c. 1700-1200 B. C.). The movements of the bull depicted in various postures on these cups is extremely accurate and realistic while the figuring of plants is so crude that the trees cannot be identified. "The natural interest in the animal rather than in the plant," says Singer, "might be illustrated by a hundred instances from Paleolithic cave paintings downward. . . ." Animal sculpture and polychrome mural decorations, including fresco-paintings of bull fights, also reached a high degree of perfection among the Minoans. The motive behind this development of animal art cannot be certainly known, but it is clear that interest in animal life was sufficient to bring about careful, systematic observation of behavior. Furthermore, the art itself could hardly have developed apart from a verbal tradition rich in animal lore.

Early Civilizations.—Inasmuch as the Assyro-Babylonian and Egyptian cultures were highly developed long before the close of the prehistoric era in western Europe, we might reasonably expect to find extensive animal observations of the natural history type occurring among these peoples. But such is not the case, and the reason for this lack is not far to seek. The animal lore of the times is inextricably bound up with esoteric beliefs and practises. In fact, it has been preserved to us very largely in connection with mythology, magic, and religious superstition of the times.

In these and other ancient civilizations, certain animals were held in high esteem. Animal cults were common, especially in early Egypt. The worship of the sacred bull of Apis representing the reincarnation of Ptah, the local god of Memphis, may be cited as a well known example. Each district, or nome, in early Egyptian times had its local divinity and these were animals more often than not. The animal was either worshipped outright or was looked upon as the chthonic (earthly) embodiment or, perhaps, merely the symbol of the god. Gods possessing human form gradually displaced the cruder animal deities as general culture advanced. In many cases the god was a grotesque composite of animal and human form. Thus we find in the Egyptian pantheon the ibis-headed Thoth, the cat-headed Pacht, the ram-headed Khnum who was so often accompanied by the frog-headed goddess Heket, and many others. This same type of representation seems to have persisted in a more refined form in the angelology and demonology of the Hebrew and Christian religions of our own time. The animal lore of these early civilizations, as embodied chiefly in their mythology, doubtless influenced the early scientific conceptions of the Greeks, as it certainly did the art and literature of all later times.

The early rise of medical cults in ancient Babylonia and Egypt [2] did not stimulate scientific

[2] It appears that medical and surgical practice was regulated by law as early as 2250 B. C. (Code of Hammurabi) in Babylonia, and pictures of surgical operations occur on the door post of a tomb discovered by

observations of animals of a very high order as might have been expected. These cults were narrowly practical in spirit, and their art represented a strange congeries of incidental observation, magic, religious superstition and astrology. The demoniac theory of disease prevailed for the most part, and exorcism by magical or religious ceremony became the accepted therapy, although rude forms of surgery and various kinds of drugs were sometimes resorted to. Certain parts of animals—usually such filthy parts as blood, fat, viscera, and excreta—when variously concocted, were thought to ward off disease, or to effect cures by magical transfer of disease to another person, animal, or object. Special potency inhered in such animals as were rare, or difficult to procure. The animal part was thought of as the bearer of magical properties rather than as a natural remedy. In striking contrast to early Greek medicine, that of Egypt and Babylonia made no worthy contribution to the natural history type of animal observation.

The ancients employed animals extensively in augury, soothsaying, and similar superstitious practices connected with the prognostication of future events. A common form of augury consisted in the inspection of the state and position of the viscera (or some part of it) of the sacrificial animal. The Babylonians, according to

Max Müller, near Memphis, Egypt, which dates back to about the same period. The famous Ebers manuscript (c. 1550 B. C.) contains, according to Garrison, 110 pages of brief descriptions of diseases and mentions over 700 remedies.

Garrison, very early developed soothsaying by liver inspection (hepatoscopy) to a fine art. Models of the liver in terra cotta, dating back some 3000 years, have been discovered, divided into squares and studded with prophetic inscriptions. "The liver as the source of blood," says this author, "was regarded as the seat of the soul, and as the god identified himself with the sacrificial animal, to inspect the liver was to see into the soul of the animal and the mind of the god."

The importance of the animal in the artistic expression of these ancient civilizations is so well known as to require no detailed comment. In sculpture, painting and other forms of pictorial representation the animal held a respectable and often a dominating place, and the same is true of the art of the story teller, and of literature after written language had developed. The exploits of animals, men, and gods find a common expression in the myth and in other types of story. The genuinely scientific motive that later gave rise to natural history among the Greeks had not as yet come to birth.

Summary.—The natural interest of primitive man in the animal life about him affords the key to the understanding of early animal lore. The life of animal and man was so intimately interpenetrated that a practical knowledge of the behavior of contemporary animal forms was essential to the survival of mankind. And when the cave man attempted to portray the objects of major interest in his environment, or sought to control that environment by magical or other

superstitious devices, pictorial and plastic art, in which the animal form predominated, made its appearance. For thousands of years this nomad observed the form and movement of animals and pictured the same upon his stone implements and upon the walls of his cave dwelling. The records show that he was often a careful observer of living nature and a skillful, realistic artisan. Much later, man domesticated certain of the animals—the dog for a hunting companion, and other species to serve as beasts of burden and as controllable sources of food and clothing.

In Babylonia, Egypt, and other ancient civilizations, the animal continued to play an important rôle in the cultural as well as the practical life of the people. The evolution of a mythology rich in animal lore, and of numerous animal cults, show this even more clearly than the animal art of these later times. The long contact of animal lore with astrology, magic and religion must have influenced the early development of natural history among the Greeks. For, as Singer says, the early Greek thinkers inherited "a great mass of observations" representing the accumulations of centuries from the earlier peoples of the Euphrates, the Tigris, and the Nile, and these became the basis of their own systems. Well directed effort to develop a comparative psychology, in connection with a scientific natural history, appears first among the Greeks, as we shall see, but the heritage of the pre-scientific ages can hardly be ignored in the interpretation of this later movement.

CHAPTER II

THE GREEK INFLUENCE

Early Greek Thinkers.—The birth of the scientific movement among the Greek philosophers of the sixth century B. C. very naturally brought biological problems of major importance to the fore. For the most part these pioneer thinkers rejected, at least in theory, the mythology, magic, and other superstitions inherited from earlier times, and attempted to find in nature herself the key to the riddle of the universe. These early thinkers are mainly important as the forerunners of Aristotle who, as the founder of natural history, zoölogy, and comparative psychology, may be taken as the embodiment of the Greek influence in these closely allied fields.

The early Greek philosophers were much concerned with the problem of the origin of life, and many of them, including even Aristotle himself, believed in the spontaneous generation of life from inorganic matter. Their speculations concerning the origin of the great variety of plant and animal forms seem to foreshadow in certain cases, as Osborn has so interestingly shown, modern conceptions of evolution. Another biological problem that led to much discussion was that of attempting to account for the apparent universality of the phenomenon of the adaptation of living forms to their natural environment, and of parts, or organs to the

functions which they normally perform. In general they were teleologists, and here again Aristotle should be included; they appealed to the principle of design, or purpose—either external or internal—to account for this, as for all other apparent harmony within the universe. Empedocles, however, dared to set forth the doctrine that nature produced myriad forms by chance and only those survived that happened to fit their environment—a notion somewhat akin to the doctrine of natural selection—and for this denial of cosmic purpose Aristotle takes him severely to task. These and other like questions, raised by these ancients, are still problems of deep concern to the modern biologist, and indirectly bear upon comparative psychology. These early philosophers were not naturalists in our modern sense. Their interest was mainly speculative and they did not make observations of animal activities of the more extensive, systematic and exact sort which later characterized the work of Aristotle.

The development of Greek art and of Greek medicine previous to the time of Aristotle aids us in understanding his own marvellous accomplishments in zoölogy. Greek art from about the seventh century downward shows, according to Singer, "a closeness of observation of animal forms that tells of a people awake to the study of nature." In illustrating the realistic animal art of the times, he cites the following representations of animal behavior among others: "We see antelopes quietly feeding or startled at a sound, birds flying or picking worms from the ground,

fallow deer forcing their way through thickets, browsing peacefully, or galloping away, boars facing the hounds and dogs chasing hares, wild cattle forming their defensive circle, hawks seizing their prey. Many of these exhibit accurate observation."

Here, as in the Paleolithic art, plants seldom appear, whereas such details as dentition, the different muscles, and the color and direction of hair, are often accurately portrayed in the animal figures. It does not seem so strange, in view of this widespread art, that Aristotle, several centuries later, should have illustrated his animal studies with anatomical diagrams.

The practice of dissection among Greek physicians extends as far back as the sixth century B. C. Singer is authority for the statement that there appears in certain writings of the famous Hippocratic Collection, probably antedating Aristotle by two centuries, and unmistakable attempt toward a classification of animals (Coan classificatory system). Observations on the nature and habits of animals, on inheritance and other related topics, are also included. Later pre-Aristotelian medical writings often involved material of general biological interest. In this connection we should remember that the father of Aristotle was himself physician to King Philip of Mecedonia, and a member of the Asclepaidæ.

Aristotle, the Naturalist.—Aristotle (384-322 B. C.) has been generally distinguished as the first systematic writer on zoölogy and as the father of natural history. He deserves with equal

justice to be considered the founder of comparative psychology. He wrote three sizable treatises on animals,[3] and two tracts of lesser importance, and in addition had much to say about animals in his other scientific and philosophical writings. To the five works mentioned should also be added his "De Anima," which treats of animal as well as human mental life, and is, in fact, much more of a comparative than a strictly human psychology in our modern sense. Inasmuch as Aristotle wrote from the larger viewpoint of natural history, his contribution to comparative psychology must be gleaned from various sources, although the major topics are systematically treated in his "History of Animals." It is worthy of note that Aristotle does not consider his zoölogical description of an organism or species complete until he has covered its psychological as well as its anatomical, physiological and developmental aspects.

Aristotle approached the study of the animal world in the true spirit of the naturalist and with the methods of the best science of his day, to which he himself was no mean contributor. According to Hertwig he may be considered as having founded zoölogy as a universal science, "since anatomy and embryology, physiology and classification find equal consideration." His classifica-

[3] The three larger treatises are: *Historia animalium,* or natural history of animals, *De partibus animalium,* or concerning the parts of animals, *De generatione animalium,* or concerning the generation of animals. The two tractates deal with the *motion* and *locomotion* of animals.

tion of animals [4] was scarcely improved upon before the time of Linnæus. Some of his findings in morphology, evidently based upon careful dissection, remained unverified by later observers until very recent times. His anatomical diagrams, to which he often makes reference, have unfortunately not been preserved to us.

The scope of his interest as a naturalist is indicated by the fact that he made reference to over 500 species of animals in his "History," and these cover an exceedingly wide range, including many exotic forms. His treatment of a given species or form comprised such topics as breeding and nesting behavior, care of the young, hibernation, methods of locomotion, feeding, fighting, migration, etc. It is evident from his detailed descriptions that he had spent many hours carefully observing bees and other insects, many species of birds and mammals, and the fishes and other marine forms that swarmed the shores of his native land.

However, we must not suppose that these writings of Aristotle are wholly, or even largely, a chronicle of his own original observations, or represent entirely his own genius. They include much that is admittedly drawn from earlier and

[4] Aristotle employed two categories in classification, the *γένος*, or group, and the *εἶδος*, or kind or species. Of the former there were eight as follows: mammals, birds, oviparous quadrupeds, fishes, mollusca, crustacea, insects, and animals with shells. The first four groups, corresponding roughly to the vertebrates, he termed *ἔναιμα* (blooded, or with red blood) as contrasted with the *ἀναιμα* (bloodless, or with colorless blood) which included the four remaining groups.

contemporary sources duly sifted and systematized by the author. His students of the Lyceum were probably responsible for certain parts of the material—notably such as do not measure up to the usual high standard of the master, either in content or form. In addition to being a pioneer investigator of supremely high merit, Aristotle had the genius to preserve for us a systematic account of the existing state of knowledge concerning the animal world. Darwin was thinking of Aristotle in the rôle of investigator when he wrote to Huxley: "Linnæus and Cuvier have been my two gods though in very different ways, but they were mere schoolboys to old Aristotle."

Aristotle's Viewpoint and Method.—Aristotle, as is well known, was both a vitalist and a thoroughgoing teleologist. He ascribes all the characteristic phenomena of living forms, both plant and animal, to the operation of an imminent vital principle or soul (ψυχή). In his conception, the individual organism like the universe at large became the natural expression of an all-pervading design or purpose; it must be thought of as the concrete realization, both in structure and function, of an inner perfecting principle, the entelechy. "Nature," as Aristotle puts it, "does nothing without aim." The soul, in the system of Aristotle, becomes the formal, the efficient, and the final cause; it determines the organization, the movement—whether inner or outer—and becomes the ultimate purpose or end of the organism. For the animal, at any rate, the soul does not exist as a separate entity apart

from the body; it comes into being when formless, inert matter (the material cause) begins to take form and exhibit living functions; it is responsible for the structure-function characteristics of the organism at every stage of the life cycle.

This vital principle, or soul, at different levels of manifestation, was held by Aristotle, to explain the whole range of functioning from the nutritive processes (assimilation, growth, decay) to the psychic activities of imagination and reason. The nutritive faculty only is found in plants; the sensory or perceptual faculty in addition characterizes even the lowest animals; most, if not all, animals possess also a third faculty involving appetites, or desires coupled with the power of locomotion as a means of satisfying such appetites. The fourth, or rational faculty is possessed in the strict sense only by man himself. The soul thus becomes, in the system of Aristotle, the all-important and ultimate principle by means of which the organism lives and moves and, under certain limiting circumstances, also reasons.

Animals are motivated by sensations of pleasure and pain, appetites, desires, and conscious purposes; self-preservation and reproduction being the natural and proper ends about which the life-activities of the organism concentrate. It occasions no surprise, therefore, to find the behavior of even the lowliest organisms described by Aristotle in the quaint terminology of conscious purpose. He ranks the sponge as little

higher than the plant world, and yet it contracts —so he thinks—when it "becomes aware of an attempt being made to pluck it" from the rocks; in boisterous and windy weather it contracts, "obviously with the object of tightening its hold." Distinctions of pleasantness and unpleasantness he finds to be coextensive with sensation, and this fact is of great importance inasmuch as "all animals pursue pleasure in keeping with their nature," and likewise avoid the painful.

Aristotle's work on animals is distinguished by the constant emphasis placed on the inductive method, in spite of its intimate connection with his general philosophical system. The conclusion to his discussion of method in the introductory chapter of his "History of Animals" might easily be taken for a statement from Bacon or a modern scientist. "Experience," he says, "furnishes the particular facts from which induction is the pathway to general laws." He insists, moreover, that these general laws must always be sought in, and agree with, observed facts. His own conclusions are often based wholly or in part upon the reports and conclusions of others, but only when such material appeared to be based upon actual observation. The immense scope of his work would naturally preclude original observation in most cases. That he is somewhat credulous in respect to hearsay and anecdote cannot be denied. Nevertheless, he is often critical of such evidence, and usually careful to specify its source so that the reader may form his own judgment.

The consistent use of the comparative method by Aristotle in dealing with the morphological, physiological or psychological aspects of the organism is very striking and offers a source of constant surprise and delight to the modern reader. Since he includes man among the animals—indeed, makes him the basic type stucturally and functionally—his method is comparative in the highest and broadest sense. Man is selected as the type evidently for pedagogical reasons, for "man is the animal with which we are all of us the most familiar," and one must needs start from the known. The comparative method in psychology is thus as old as the science itself, since both find their beginning in Aristotle.

The Senses of Animals.—There are only five senses, according to Aristotle, in either animal or man, namely: touch, taste, smell, hearing and vision. He assumes the presence of touch in all organisms and attempts to determine the presence or absence of the other four senses in each of his main groups of animals. His first appeal is to inference from structure; if a sense organ is present, roughly analogous to that of man, no further evidence is required. A wolf, for example, must possess smell, hearing, and vision, since it has the appropriate organs, nose, ears, and eyes. The question of essential and accessory structure apparently did not enter. In the absence of a given sense organ, or when such could not be certainly identified, recourse was had to behavioristic evidence. The response of the organism to characteristic stimuli, or the re-

port of such response by other observers, was taken as evidence. In any case observations were rough and uncontrolled and almost wholly lacking in scientific value. Much of Aristotle's evidence in this field appears to be drawn from the folklore of the times.

The following illustrations are fair examples of his data and method. The scallops probably possess vision, since they close their valves when the finger is moved toward them "as if they could see what you are doing." The selection of certain flowers, and especially the fresh sweet ones, by the bee in foraging affords convincing evidence that insects possess the sense of taste. The octopus and the crayfish distinguish smells, since they can be caught by bait, or dislodged from rocks by fleabane. Likewise the power of smell is proven in the eel by the fact that an earthen pot that has previously contained pickles makes an excellent eel trap. That fishes possess smell is shown by the fact that different baits are used more effectively for different kinds of fishes, and by the hearsay reports that aggregations of fish swim away from the foul fish-washings that are cast overboard by fishermen.

In view of the present controversy over the question of hearing in fishes, the observations of Aristotle on this point are interesting. He cites, as positive evidence, the fact that the bull-head, a river fish which burrows under the rocks, can readily be frightened out of its hiding place by dropping stones in the water above, which make a clattering noise on striking its rocky hiding

place. Shoals of dolphin, he avers, are "stupefied with the noise" and easily caught when a loud splashing in the water with oars is made by fishermen. He cites a few similar cases, and then naïvely concludes: "From these facts it is quite obvious that fish can hear; and indeed some people from living near the sea and frequently witnessing such phenomena, affirm that of all living creatures the fish is the quickest of hearing."

His final conclusion concerning the distribution of the senses in animals is that mammals, birds, oviparous quadrupeds, and fishes possess all five senses. Of the other four groups, corresponding roughly to our invertebrates, he finds that the mollusca (cephalopods), crustacea, and insects have all the senses except possibly hearing; while the lowest group (sponges, cœlenterates, etc.) possess only touch, taste and smell.

Having settled to his own satisfaction the question as to the distribution of the senses, Aristotle apparently feels that his task is done. He does not mention the problem of range and intensity differences in the various senses in different species, other than to make a general statement occasionally concerning the special development of one or another sense in a given species. Nor does he consider the matter of possible differences in the subjective quality of the sense impression from different types of sense-organ representing the same sense. To Aristotle an ear was an ear and an eye an eye "and nothing more." While holding in general that man is the perfect animal, he freely admits that some one sense in certain

animals is much superior to that same sense in man.

Memory and Intelligence of Animals.—Concerning the higher intelligence of animals Aristotle makes the statement that "many animals have memory and are capable of instruction; but no other animal except man can recall the past at will." This difference is apparently the most fundamental one between the animal and the human intellect, as he sees it. The higher animals may, and many of them do, possess a passive imagination involving the revival, under appropriate conditions, of residual sense-impressions. But they do not possess the active or creative imagination based upon voluntary recall which is so characteristic of the higher rational life of man.

Animals have a certain practical intelligence; a low order of inference may be exhibited on occasion. For, "just as we find in man knowledge, wisdom, and sagacity, so in certain animals there exists some other potentiality akin to these." And while "of all animals man alone is capable of deliberation," some animals possess "something akin to sagacity." As evidence of inner representation of some sort he appeals to the apparent dream life of animals. Practically all mammals dream, in his opinion, and dogs "show their dreaming by barking in their sleep." In general, however, Aristotle is of the opinion that the animal is pretty much the slave of present stimuli, the memory image being invoked even in the higher types only on occasion. Although

he finds that "in the great majority of animals there are traces of psychical qualities or attitudes," this need not mean more than that they are sensitive to sense impressions.

In thus marking off man from the other animals as possessed of creative imagination and the true rational faculty, Aristotle is evidently speaking of the normal adult mind. For he states in this connection that "in children may be observed the traces and seeds of what will one day be settled psychological habits, though psychologically a child hardly differs for the time being from an animal." The rational element in the mental makeup thus becomes the important criterion of the higher and human, as contrasted with the lower and animal—a distinction which has prevailed for the most part from that time forward in the field of psychology.

Little evidence is brought forward to illustrate higher intelligence in the animal world. Such cases as are cited are chosen without distinction from both the so-called instinctive and learned types of response. This is significant as indicating that Aristotle made no clear-cut distinction between instinct and intelligence. And it is doubtful whether such a dichotomy was made until many centuries later, although Galen (c. 130 A. D.) and certain of the later Roman writers appear to make the distinction fairly definite.

The evidence for animal intelligence which Aristotle cites is mostly commonplace observation and anecdote. He speaks of a certain species

of spider as "preëminently clever and artistic" on account of the fact that it is able to build a web of unusually intricate design. A domesticated woodpecker had been seen to insert an almond into a hole in a piece of timber "so that it might remain steady under its pecking" according to the report. In the vicinity of Lake Maeotis, so he had heard, "wolves act in concert with fishermen, and if the fishermen decline to share (the catch) with them, they tear their nets in pieces as they lie drying on the shore of the lake." But it is the elephant over which Aristotle waxes the most enthusiastic. It is "of all wild animals the most easily tamed and the gentlest." Furthermore, "it can be taught a number of tricks, the drift and meaning of which it understands; as for instance, it can be taught to kneel in the presence of the king. It is very sensitive, and possessed of an intelligence superior to that of other animals." Man, then, is the most intelligent of animals, and the elephant next; the relative position of the remaining types in the scale of intelligence was apparently left for later generations to determine.

Temperament and Emotional Life.—The observations of Aristotle relative to the temperamental and emotional life of animals are of the most general and desultory sort. He does little more than enumerate the human passions which he ascribes to the higher animals without hesitation. His contribution at this point is mainly that of recording commonplace opinions drawn from the animal lore of his day. The following

quotation from his "History of Animals" is a fair sample of his manner of treating this topic:

Animals also differ from one another in regard to character in the following respects: Some are good tempered, sluggish, and little prone to ferocity, as the ox; others are quick tempered, ferocious, and unteachable as the wild boar; some are intelligent and timid, as the stag and the hare; others are mean and treacherous, as the snake; others are noble and high-bred, as the lion; others are thoroughbred and wild and treacherous, as the wolf; . . . Further some are crafty and mischievous as the fox; some are spirited and affectionate and fawning, as the dog; others are easy tempered and easily domesticated, as the elephant; others are cautious and watchful, as the goose; others are jealous and self-conceited, as the peacock.

Concerning sex differences in temperament he writes:

In all cases, except those of the bear and leopard, the female is less spirited than the male . . . with all other animals the female is softer in disposition than the male, is more mischievous, less simple, more impulsive, and more attentive to the nurture of the young.

The male is described as being more savage and less cunning. The sex difference is greater, in his opinion, among the higher types, and especially so in the human species. Woman is more compassionate than man, he declares, but is also more jealous and querulous, more given to despondency and pessimism, "more void of shame

or self-respect, more false of speech, more deceptive" and more shrinking and cowardly. That the male is more courageous than the female he illustrates by the alleged fact that the male cuttlefish will aid the female in avoiding capture, while the female will scurry away when the male is attacked, leaving him to fight alone.

It will be noted that many of the terms employed by Aristotle to describe the animal temperament are those used in common speech to designate character traits in human beings, and have a more or less specific ethical connotation. And it can hardly be doubted that Aristotle meant that these terms should carry the usual ethical implications in his characterization of animals. Craft and treachery, jealousy and self-conceit, nobility and courage were applicable to man and animal alike. Sex behavior is treated in much the same vein. He speaks of the mare as being the "most sexually wanton" of animals; of the partridge as "salacious" because of its frequent copulation, while the crow is "inclined to chastity" for the opposite reason. These statements are much more than merely anthropomorphic figures of speech; they are, in fact, the logical outcome of the all-embracing teleology that was fundamental in Aristotle's systematic interpretation of the Universe.

Later Greek and Roman Writers.—Interest in the animal division of natural history gradually declined after Aristotle. The later Greeks following the natural bent of the Hellenic mind engaged themselves in philosophical, and partic-

ularly ethical speculation. The Romans in general borrowed their natural science from the Greeks, and produced no investigator of consequence in this field. Plutarch and Galen from among the Greeks, and two Roman writers, Seneca and Pliny, may be taken as representative of the half-millennium following Aristotle. These will be treated briefly in chronological order.

Seneca (54 B. C.-39 A. D.) gives a good account of the viewpoint of the Stoic concerning the intelligence of animals. He denies to the animal the power of reason; man alone is rational and capable of ethical conduct. Any similarity between the mental faculties of man and animal is only apparent. The lion does not feel genuine anger when it stands ready to tear the passerby in pieces; the animal who may save a man's life is not possessed of a feeling of generosity, or of desire to be of service. Animals are unable to recall past experience, their memory capacity being limited to recognition. Thus the horse may recognize a road over which it has traveled before but remembers nothing of it when in the stable afterward. Seneca seems to make a clear distinction between native and acquired behavior. The former is marked by uniformity, "takes place without reflection," and involves only such knowledge as is necessary for self-preservation. As the Stoic exalted the rational faculty, so also he exalted man, the rational animal, and set him apart in sharp contrast to the brute creation.

Pliny the Elder (23 B. C.-79 A. D.), a Roman

general, was a compiler and popular writer in the field of natural history. His "Natural History" is an encyclopedic collection of "anecdotes, sayings, traditions, and citations from earlier writers" and from contemporary sources, covering a wide range of scientific topics (20,000 as he claimed). He held the mental powers of animals in great esteem and in the section devoted to animals (books 8-11) includes many anecdotes to support his opinion. He is especially impressed by the honesty, discretion, sense of justice, docility and memory capacity of the elephant. He cites its public performances in the Roman amphitheatre—dancing in concert, wielding arms, walking ropes, and similar stunts. He tells of one elephant that was found practicing his dancing lesson alone at night in the moonlight after being punished severely for doing poorly that day; of another who could write the following sentence in Greek, "Ipse ego haec scripsi, et spolia Celtivi dicovi." Although Pliny's work was thoroughly uncritical in spirit, it was widely read in his own day and for centuries later.

Plutarch (c. 46-120 A. D.), the noted biographer, discussed at some length his own and current views concerning animal intelligence. He opposed the view of the Stoics that animals have no real thought or feeling life. He brings forward, after the manner of Pliny, much anecdotal evidence to prove the sagacity and human-like emotional capacity of the higher animals.

Galen (c. 130-200 A. D.) has been called the founder of experimental physiology and experi-

mental medicine, and his voluminous writings on anatomy were the accepted authority until the time of Vesalius (sixteenth century). He dissected a large number of mammalian types including an elephant and many apes. He was the last and perhaps the greatest biological investigator of the Alexandrian school of Greek science. Although he was primarily interested in anatomy and in function in the narrow, physiological sense, there are scattered throughout his works many original observations of animal behavior. An interesting example is that of a kid found to be alive after dissection from the mother and "snatched away before it saw its dam." The kid, he observes, first got upon its feet and walked, "then it shook itself, and afterwards scratched its sides with one of its feet." Upon being released at once in a room where Galen had placed vessels containing wine, milk, various other liquors, grains, fruits, etc., it smelled of them all and finally drank the milk. Galen insistently calls attention to the apparent adaptation of structure to function which he sees everywhere, and seeks to explain this by the principle of design. As Holmes has pointed out ("Studies in Animal Behavior," p. 12), he shows an approach to the concept of instinct as this term came to be used by later writers.

Summary.—The contribution of the Greeks to comparative psychology as well as to most other aspects of zoölogical science may be summed up in the person and works of Aristotle. He preserved to us a systematic account of the ex-

isting state of knowledge based upon his own wide observations and the winnowings of the animal lore of earlier times. His conception of the animal and of its behavior was vitalistic and teleological and his interpretations naïvely anthropomorphic—due to the fact that his biological observation and his philosophical speculation were intimately related. His work is marred by a rather extensive use of the anecdotal method. He emphasized the importance of the inductive method both in theory and practice, and developed psychology as well as general biology along broadly comparative lines. He was a careful, patient investigator and probably made a greater contribution to comparative psychology than any other writer previous to Darwin.

The decline in the natural science type of animal study was rather sharp. Later Greek and Roman writers turned to metaphysical and ethical speculation, or became mere compilers along scientific lines. The Stoic stressed the distinction of Aristotle between man, the rational animal, and the remaining animal world much more than he himself had done. By the time of Galen, who stands out as the only important Greek investigator after Aristotle, a fairly definite concept of instinct appears to have emerged. The foundation had thus been laid for a sharp dichotomy between man and the brute creation—the one possessing reason and guided by experience, the other endowed with an instinctive life in which individual experience plays at most a subordinate rôle. This distinc-

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tion was further developed as we shall see, in connection with the doctrines of the church and became the ruling conception in the discussions of the mental life of animals during the middle ages.

CHAPTER III

THE EARLY AND MIDDLE AGES

Early Influences.—The rise and spread of Christianity, among other things, hastened the decline of natural science to the low level characteristic of the early and middle ages. The world-renouncing attitude fostered by early Christian teaching later developed into one of contempt for natural phenomena and of open hostility to the observation of nature. Man and his redemption became the one problem of supreme importance, and the animal was degraded and despised in common with the physical world. A sharp dichotomy was drawn, on theological grounds, between mankind and the beasts that perish, by placing undue stress upon the superiority of the one and upon the inferiority of the other. Reason was denied the animal in strictly orthodox circles, inasmuch as the possession of reason might also imply moral responsibility and the possibility of redemption and immortality. Aristotle had assigned to man, as the most perfect animal, the highest place in the economy of nature; Christian theology placed him outside and above nature, insofar as his most fundamental relationships were concerned.

The influence of this theological conception was strengthened by the fact that education gradually passed into the hands of the ecclesiastical authorities where it remained for centuries. Greek science, except for the medical system of

Galen, was looked upon with the same suspicion that attached to pagan culture in general. The natural science of Aristotle, translated by the Arab scholars, first in the eighth, and later in the tenth and eleventh centuries, exerted little influence on Christendom until the time of Albertus Magnus. Aside from the Bible, Pliny and the "Physiologus" were the most popular sources of information on animals during the millennium immediately following Galen.

The "Physiologus" was a popular work on natural history, dating back at least to the third century (A. D.), dealing with stones, trees and animals, and appears to have been widely circulated in one form or another even as late as the twelfth century. It came in time to include only animals and was then called the Beastiarius. It treated about 70 animals, many of which were such mythical forms as the dragon, basilisk, unicorn and phoenix. It was issued in both prose and poetical form and was often beautifully illustrated. Very early the natural history element in it became subordinated to the allegorical; the animal stories were made to symbolize moral and religious beliefs. The following from Locy (who quotes from White one of the stories on the lion) will serve as an illustration: "The lioness giveth birth to cubs which remain three days without life. Then cometh the lion, breatheth upon them, and bringeth them to life. . . . Thus it is that Jesus Christ during three days was deprived of life, but God the Father raised Him gloriously." Authorities differ

widely in their opinion as to the magnitude of the influence of the "Physiologus" during the middle ages. It appears to have been quoted by Albertus Magnus and contemporary encyclopedists of the thirteenth century.

The Revival of Aristotle.—The latter part of the middle ages, and notably the thirteenth century, was marked by the revival of the writings of Aristotle on natural history and other subjects. There also appeared the beginnings of independent observation which, however, in things biological made little headway previous to the opening of the sixteenth century. The writings of Aristotle, as of the Greek philosophers generally, had been preserved by the Saracens during the preceding centuries. Avicenna (980-1037) had written a paraphrase of parts of Aristotle's works on natural history and Averroes (1126-1198) had issued a commentary on the "History of Animals," not to speak of earlier Arabic translations. But stubborn opposition to "infidel," as well as to earlier pagan culture, prevented this revival of Aristotle among the Moslems from exerting any great influence upon Christendom, although the fact must not be overlooked that many Christian students attended such famous Mohammedan universities as that at Cordova. It was necessary that the works of Aristotle be made acceptable to the ecclesiastical authorities and be widely distributed if the new learning was to prevail.

Before we speak of the work of Albertus Magnus and the encyclopedists who were to accom-

plish these important ends, brief mention should perhaps be made of Adelard of Bath, a traveler and scholar of the twelfth century. In his well known treatise "Quaestiones Naturales" he sets forth, in the form of a dialogue with his nephew, the ideas gathered from years of searching for wisdom in many lands, and particularly those of Arabian scholars. "Adelard upholds scientific argument and investigation against a narrow religious attitude," and places reason above authority. At one point in the discussion the nephew asks: "Would you now discuss the question as to whether brutes have minds?" Adelard replied, "On this point there is today a difference of opinion. The common people unhesitatingly say no, while philosophers are equally confident about the opposite." He then proceeds to offer reasons for this latter view, as held by the Arabs, which sound strikingly Aristotelian, and probably represent the influence of Aristotle on Arabian culture. Adelard was a contemporary of Averroes, as well as of Abelard of scholastic fame.

Albertus Magnus (1206-1280) may be considered the outstanding figure of the thirteenth century in the field of natural history and, therefore, of the middle ages taken as a whole. For it was mainly through his efforts that Aristotle's natural history was made acceptable to the Church authorities; and we must not forget that even as late as 1210 the science of Aristotle was proscribed at the University of Paris. Furthermore, Albert stoutly upheld "the rights of

observation, experience and induction" (de Wolf), and was undoubtedly himself a naturalist of considerable ability. His "De Animalibus" is a paraphrase of Aristotle's "History of Animals," with comments of his own, and with an addition of 7 books (the whole comprises 26 books) which represent material not found in Aristotle, drawn largely from other previous writers and from his own experience. Albert has no scruples against rejecting the opinions of the ancients when these do not coincide with the observations of himself or of his contemporaries. He was critical enough to reject much of Pliny, and to make a clear distinction between actual observation and hearsay information, when evaluating the materials of other writers in this field. His general point of view is essentially that of Aristotle except for the fact that he makes a sharper dichotomy between man and animal in accordance with his theological prejudices. Animals, he thinks, are "directed by their natural instinct and therefore cannot act freely"; the behavior of the insect is not accompanied by intellectual activity, but results from "natural dispositions" as shown by the fact that "they act always in the same way." Their behavior is nevertheless purposive even though not deliberative, and at its best involves a sort of practical judgment (*vis æstimativa naturalis*). In brief, Albert is Aristotle with a theological bias.

The revival of Aristotle was also furthered by the contemporary encyclopedists who included

as a rule large sections on animals compiled from every available source. The largest of these encyclopedias, the "Speculum Majus" of Vincent of Beauvais, a Dominican, includes six books devoted to animals and plants (Locy). That of the Franciscan, Bartholomew Anglicus, "De Proprietatibus Rerum," enjoyed a wide circulation, being translated into most of the vulgar tongues of Europe before the opening of the 16th century. As Locy says, this latter was the book from which Shakespeare and other Elizabethan writers drew much of their knowledge of nature. Thomas of Cantimpré wrote "De Naturis Rerum," which was translated about the latter part of the 14th century by Conrad von Megenberg as "Das Buch der Natur," which, in this form, was widely circulated in Germany. All three encyclopedias appeared about the middle of the 13th century, and drew heavily upon Aristotle for their natural history material. They made no claim to originality and the compilations show a considerable lack of critical judgment. Nevertheless, they were important agencies in the dissemination of what was then known about the animal world, and in the revival of the Aristotelian tradition. The spirit of Aristotle, with its emphasis upon empirical fact and method, however, did not fully awake until after the scientific revival of the 16th century.

Other Influences.—The thirteenth century was the age of Roger Bacon as well as of Albert, and both of these leaders were strong advocates

of the use of the inductive method in natural science. Pouchet has rated Albert as "the greatest genius of his time," although this rank is usually accredited to Bacon. Both were very far from being modern experimentalists, as Lynn Thorndike has shown; both were, in fact, often victims of childish credulity, and believers in the black art in one form or another. Thus we find Albert believing in the secret power of gems and reporting that when a ring was once drawn around a toad and an emerald, the latter "began to crack like a nut" and broke apart when the toad gazed at it unswervingly for a short interval, after which the toad moved away "as if it had just been freed from the power of the stone." Albert had expected the toad to burst instead, provided the gem was "in full vigor," which apparently was not the case. He is also much impressed with the value of various parts of a lion to cure madness, jaundice, cancer, and to keep away moths, etc. Bacon also believed in the magical power of gems, plants, and certain animal parts, and attributed this power to the influence of the stars. He tells of a snake cut into small sections, except that the skin of the belly was left intact, which crawled to a certain plant and was "instantly made whole" by touching it. Superstitions of this sort were widespread among the populace and hindered the development of a genuinely scientific natural history.

The attitude of the Church on animal intelligence during the later middle ages is best repre-

sented, perhaps, by the famous pupil of Albert, Thomas Aquinas (1225-1274). These two Dominicans were both devoted to Aristotle and hold much the same general viewpoint regarding the nature of the animal mind. Both make a sharper distinction than their master had done between the rational soul of man and the sensitive soul of the animal, although Aquinas admits that the human embryo possesses at first only the latter, "a more perfect one which is both sensitive and rational" being provided by act of deity at some point before maturity. Animals "do not work like intellectual agents, in diverse and opposite ways, but just as nature moves them to fixed and uniform specific activities." Here, as with Albert, the behavior of the animal is essentially instinctive, while that of man is rational and involves freedom of choice. Instinct and reason, man and beast were thus set in contrast; the distinction that Aristotle the naturalist had been unable to make in this strict sense, was made by the theologians, and largely on religious rather than scientific grounds.

Summary.—This period was one of dearth so far as the investigation of the mental life of animals is concerned. Natural history study sunk almost to the low level characteristic of the ancient civilizations of the pre-scientific age. The animal was either ignored along with the world of nature in general, or became the subject of superstitious beliefs. In the early part of the period the ignorance of the masses and the hostility of theology to natural science observa-

tion were largely responsible for the retrograde condition. In Adelard of Bath, a pioneer thinker of the twelfth century, we note the beginnings of a reaction against the prevailing view. The following century witnessed the revival of Aristotle's works on animals in Christendom, largely through the influence of Albert. The contemporary encyclopedists also aided in stirring up an interest in the animal world, inasmuch as their writings, compiled from Aristotle and other authors, were widely circulated. The orthodox view of the later middle ages made instinct and reason antithetical, and established a sharp dichotomy between man and the beasts that perish. The revival of Aristotle, however, marked a great forward step, since the "Physiologus" and Pliny had been the earlier favorites. Once the writings of Aristotle were accepted, they became a new source of authority rather than a stimulus to further observation of animal activities. This in part accounts for the fact that there was little genuine progress before the revival of science in the 16th century.

CHAPTER IV

FROM THE SIXTEENTH CENTURY TO DARWIN

The Scientific Revival.—The 16th century witnessed the awakening of a new spirit of inquiry in the biological as well as in other scientific fields. The later middle ages had scored a great advance by the revival of Aristotle's zoölogical writings, but had failed to carry the advance forward materially, because of their slavish adherence to Aristotle as a source of authority. During the sixteenth century, however, man began to show signs of outgrowing authority and of placing more dependence upon his own capacity to observe, analyze, and interpret the facts of nature at first hand. The spirit of Aristotle, the pioneer investigator, was beginning to replace the literal content of his works; the compiler began slowly to give place to the naturalist. This spirit of revolt against ancient authority in biology is fitly typified by the attack of Vesalius, about the middle of the century, against the anatomy of Galen—almost a half century, indeed, before the time of Galileo and Francis Bacon, and in the same year that Copernicus published his celebrated treatise on celestial mechanics.

The three centuries from Vesalius to Darwin were crowded with new discoveries and new developments in the biological field. Many of these were only indirectly related to comparative psychology, which was relatively late in com-

ing into its own, and therefore they deserve only brief notice in this connection. The emphasis at different times was upon classification, morphology (anatomy, histology, etc.), physiology, embryology, evolution and other major divisions of zoölogy. The last century of this period was especially marked by the breaking up of zoölogy into the various subsciences much as we know them today. Several general lines of development within the field may be clearly distinguished. One of these, as Geddes has pointed out, has been the tendency toward a finer analysis of both the structure and function of the organism as smaller and smaller units (organism, organ, tissue, cell, protoplasm) have become fundamental for a given subscience. Another development was the tendency of the various zoölogical disciplines to become broadly comparative, and especially so since the evolutionary conception has become dominant in biology.

The interest in the problems of comparative psychology during the greater part of this period was largely speculative, arising in connection with theological or metaphysical questions. While solid advances were being made in most other fields of zoölogy, only sporadic and often ill-devised and biased investigations of animal behavior took place. In fact, it was the revival of the doctrine of evolution, especially by Darwin and his followers, that stimulated an interest that has since developed into the present-day movement in this field. The search which was

then begun for evidences of mental continuity throughout the world of living organisms, and for clues to the *modus operandi* of mental evolution, has gradually broadened into the comparative psychology of today, which attempts to deal systematically with the entire mental life of the animal.

The Sixteenth Century Naturalists.—The encyclopedic type of natural history prevailed for the most part during the century under review. However, the scope of these books was usually limited to a description of the animal world and did not include nature as a whole; that is, the *opus naturarum* of the thirteenth century was now replaced by the *historia animalium,* indicating that zoölogy had separated from botany as well as from the other major fields included in natural history taken in the broadest sense of the term. A further restriction of scope, making possible more intensive investigation of selected fields, occurred in some cases as illustrated by a number of treatises dealing exclusively with a single large group of animals, such as fishes, birds, aquatic animals, etc. Compilation from Aristotle and other ancient writers was still the general rule, although descriptions and figures based upon direct observation were also common and were gradually coming to the fore. The spirit of adventure was in the air and exotic forms procured through discoveries in America and other new lands, and from wider travel in tropical Europe and Asia, were not without an important stimulating effect. This century was,

however, essentially a period of transition in which the ancient and mediæval undoubtedly still outweighed the newer element.

The "Historia Animalium" of Gesner, the famous Swiss naturalist, which began to appear in 1551, is the best of the strictly encyclopedic type of work. The five volumes comprised about 4500 folio pages, contained over 1000 illustrations, and represented the siftings of some 250 writers, together with much material collected by Gesner from his widely scattered correspondents (Locy). Gesner's primary classification of animals is that of Aristotle as modified by mediæval writers. Under these main groups he merely listed the species alphabetically except when closely allied forms were grouped together as a matter of convenience to the reader. The scope and general character of the work can be seen by noting the topical scheme which was followed in so far as possible in the case of each species: name of animal in different languages; native country, habitat, and general appearance; mode of life; habits and instincts; methods of capture; rearing, etc.; use as food; use as medicine; literary, sacred and magical usage. The book was written primarily to serve the popular interest, and contains no important original generalizations, being purely descriptive in nature. Although the author exercised, for the most part, great care in the selection of his material, such fabulous monsters as the winged dragon, polyheaded hydra, crowned basilisk, etc., were included in the work. While the content was com-

piled very largely from earlier writers, much of it is supported by the corroborative observations of Gesner and his contemporaries. Gesner was the most learned naturalist of the 16th century and, in the opinion of Locy, the most influential zoölogist between Aristotle and Ray. His history was translated into several languages, was regarded "as the standard reference work on animals down to the time of Linnæus," and was widely used for a long time thereafter on account of its many illustrations (Locy). About a half century later, Aldrovandi, an Italian physician and naturalist, attempted to bring together all that was then known of the animal kingdom, much after the order of Gesner. Thirteen volumes of the still-uncompleted work were published, but it never enjoyed the wide circulation of Gesner's history. Wotton's "De Differentiis Animalium" (1552) is little more than a reworking of the natural history material of Aristotle, although it represents a great advance over the paraphrase of Albert three centuries earlier.

The influence of the scientific awakening is more clearly evident in the less pretentious works of Belon, Rondelet, Turner and other naturalists who devoted themselves to the intensive study of selected groups of animals. After traveling extensively in Europe, Asia Minor and Egypt, Belon wrote his History of Birds (1555) figured from nature, in which about 200 species, including several exotic forms, are treated. Later he wrote a treatise on fishes and another on aquatic animals, having made extensive studies on these

forms in his travels and by means of regular visits to the markets of Venice. Rondelet, under whom Gesner studied anatomy at Montpellier, published a treatise on marine fishes (1554) and another on aquatic animals (1555). These works comprised some 259 species in all—most of them figured—and were used extensively by Ray and Willoughby about a century later, and indeed became, in the opinion of Miall, the foundation of modern ichthyology. The English naturalist, Turner, wrote (1554) a history of the birds mentioned by Aristotle and Pliny to which he added a section covering his own observations on the birds of England. This work was considered valuable enough to warrant translation recently (Evans, 1903). Even in these more restricted studies which represent the best effort of the times, there is a curious mixture of compilation (often, however, verified by direct observation) and genuinely original investigation.

The philosophers and theologians of the period continued to emphasize the distinction between instinct and reason, and thus setting in opposition man and beast. The naturalists were, as usual, inclined to be generous to the subjects of their study and often revelled in an anthropomorphism that was positively ludicrous. Something of the temper of the times is shown by the discussion of the famous essayist Montaigne writing during the latter half of the century. He takes sides with the naturalists and does not hesitate to ascribe a high order of imagination, forethought, and deliberative reason to the ani-

mal. It is unreasonable, he thinks, to suppose that "mere instinct with a kind of unknown, natural and servile inclination" can account for the spinning of the spider web or the building of the nest of the bird. The decision of the fox not to cross the river when the ice is too thin, as reported in Thracian legend, is reached by "a kind of debating reason and consequence, drawn from natural sense." In fact, he insists that the fox listens to the roaring of the water and then considers the logic of the situation in some such manner as this: "Whatsoever maketh a noise moveth, whatsoever moveth, is not frozen; whatsoever is not frozen, is liquid; whatsoever is liquid, yields under any weight." Thus we see that the interpretation of animal activity depended, then, as now, to a large extent, upon temperament and personal prejudices, or upon philosophical and theological predilections—hence the divergent and contrasting viewpoints.

The Controversy Between Vitalist and Mechanist.—The outstanding movement of the 17th century, so far as comparative psychology is concerned, was the revolt against the traditional vitalistic interpretation of the organism, which traced back to Aristotle. For Aristotle, physiology as well as psychology had a soul, and inasmuch as this fitted in well enough with the mediæval temperament, the notion had never been seriously questioned. Vital phenomena were referred to a nutritive or sensitive soul or to some analogous vital principle. But the great advance in physics that ushered in the 17th cen-

tury—for this was the age of Galileo and Bacon —together with the success of Harvey in explaining the circulation of the blood along mechanical lines, naturally turned the mind of both philosopher and physiologist toward mechanistic interpretations of biological phenomena.

The extreme mind-body dualism of Descartes (1596-1650) amounted to a flat rejection of the nutritive soul of Aristotle in favor of a purely mechanical explanation of bodily processes. The mind of Descartes corresponded roughly to the rational soul of Aristotle broadened to include all conscious or psychic functions, many of which Aristotle had placed in the sensitive soul. Mind and matter were antithetical concepts and everything in the universe belonged under the one or the other category. The body, as matter, had no essential connection with the imperishable, immaterial mental substance—the spirtual soul—that inhabits it while living. The animal must either be granted an immortal soul or be classed along with man's body as a purely physical machine. Descartes chose the latter alternative and held that the animal is a natural machine (la bète machine). He accepted the logic of his position to the extent of denying even sensations to animals—though he appears to have modified his view later, admitting the possibility of vague sensations and desires. He boldly claimed to be able to explain the apparent cunning and sagacity of the higher animals, and the operation of lust, hunger, and fear by mechanical principles alone. "Were there," he says, "machines exactly re-

sembling in organs and outward form an ape and other irrational animal, we could have no means of knowing that they were in any respect of a different nature from these animals." And Malebranche, a follower of Descartes, asserted that such animals as dogs and cats "eat without pleasure, cry without pain—grow without knowing it—desire nothing—know nothing," and are able to make apparently intelligent adjustments only "because God, in making them for self-preservation, has constituted their bodies in such a way that they withdraw organically and without knowing it from all that can destroy them and that they seem to fear." The Cartesian doctrine, although mechanistic, engendered no conflict with the orthodox theology of the times, since it left the soul intact and upheld the primacy of man. Descartes himself declared that "after the error of atheism, there is none which leads weak minds further astray from the path of virtue than the idea that the minds of animals resemble our own, and therefore that we have no greater right to future life than have gnats and ants. . . ." It is interesting to note in this connection that Leibniz, while denying conceptual reasoning to the animal, openly opposed Descartes' notion of degrading it into a simple machine; he granted it a continuity of perception analogous to reason, and of the same order as three-fourths of man's own mental life. Furthermore, he held that animals were immortal.

The chief exponent of the mechanistic position among the physiologists was Borelli (1608-

1679), founder of the iatrophysical school of medicine. He gave his best thought for many years to an attempt to explain the various movements of animals (including the human) as resulting from the operation of physical principles. In his "De Motu Animalium" (1680-81) he seeks to apply in specific cases his mechanical theory, which is similar in many respects to that of Descartes, which appeared earlier. He substituted the concept of nervous fluid operating in a purely physical manner for the notion of incorporeal, or quasi-corporeal animal spirits current in his day. He and his pupils carried out many careful experiments in their attempt to free physiology from its vitalistic heritage.

The reaction against the mechanistic view was led by the physiologist Stahl, who wrote during the first half of the following century. Stahl, strangely enough, was a product of the intrachemical school of medicine founded by Sylvius, a contemporary of Borelli. Stahl rejected the chemical explanations of Sylvius, insisting that the chemical changes occurring in the living organism are essentially different from those taking place in the laboratory and in non-living matter. Stahl seems to have harked back to Van Helmont, a contemporary of Descartes, for his general viewpoint, or, perhaps, even earlier to the noted physician Paracelsus (Brett). In place of a chemical and physical explanation of life phenomena, Stahl reverts to the doctrine that the soul is the primary cause of chemical and physical change. The soul, as he conceives it,

pervades every part of the organism, builds the body for its own ends, and is linked to the body in some mystical fashion in motion or functioning. Since the chemical events themselves are under the control of the sensitive soul, the latter becomes the *vera causa* of all inner and outer behavior, and hence explains both the physiological and psychological aspects of the organism. The influence of vitalism upon physiology has not been easily broken. For even the eminent Johannes Müller, and other important physiologists of the nineteenth century, held some form of vitalistic theory; and in our own day there is, of course, Driesch.

Some Eighteenth Century Developments.—So many interests are represented in the zoölogical work of the eighteenth century that only the briefest notice can be taken of the more important movements. As we have already noted, specialization and more intensive investigation were gradually replacing the older or encyclopedic type of natural history. In Buffon, as Geddes has said, the old school "found at once its highest outcome, its monument and its grave." His "Natural History" (44 volumes) which began to appear in 1749 was a marvel of literary charm and beautiful illustration, and must be ranked as one of the most important forces of the century in popularizing natural history. As a work of science, however, it belonged to the preceding century; for Buffon either ignored or openly flouted the work of Linnæus, Réaumur and his school, and other advance movements of his time.

The first edition of the "Systema Naturæ" of Linnæus was published fourteen years before the first volume of Buffon [5] appeared. This work as finally developed marked the beginning of modern systematic zoölogy and opened a new epoch in descriptive natural history. In this work precise, diagnostic and brief, usable description replaced the accidental, general and verbose description of the older type. Accepting Ray's definition of a species (as composed of forms similar and interfertile) Linnæus arranged the animal kingdom into a tentative hierarchy of groupings, and invented the binomial nomenclature. He thus provided zoölogy with working tools of primary importance to its further progress; and this, even though the immediate effect was overemphasis on mere classification among the systematists. The tenth edition of the "Systema Naturæ," which is still the basis of taxonomy, included 4378 species, or nearly ten times as many as are mentioned in the "History of Animals" of Aristotle. The systematic movement continued at the level set by Linnæus until the first quarter of the nineteenth century when comparative anatomy, as the basis of classification, was introduced by Cuvier.

Pioneer studies on lower forms during this century deserve mention. Even in the seventeenth century the microscope had been instrumental in opening up several new and important fields. Leeuwenhoek had discovered protozoa in 1675, spermatozoa in 1677, and bacteria in 1683;

[5] Miall gives a good treatment of Buffon.

Malpighi had observed the developing embryo of the chick under the glass, and both he and Swammerdam had drawn with infinite care the marvellously minute and complex anatomy of the insect. This work was developed during the present century by Reaumur, whose 6-volume "History of Insects" was completed in 1742, and by his school of microscopists or zoötomists. Lyonet, Bonnet, Roesel von Rosenhof and De Geer all spent years of painstaking effort on insect anatomy, and preserved their work in handsomely figured monographs, or in more general treatises. Investigations were also made of the various stages of insect metamorphosis. The brilliant work of this group was carried forward in the nineteenth century by Straus-Durkheim, Dufour, Newport (who introduced embryological technique), and Leydig, who introduced histological method and made this branch of anatomy broadly comparative. The hydra-experiments of Trembley, published in 1744, on regeneration and the aphid-experiments of Bonnet, reported the following year on parthenogenesis stirred up much discussion at that time, and both represent the beginnings of an important line of modern research. The establishment of epigenesis by Wolff (1759) in opposition to the traditional preformation theory, stands out also as one of the landmarks of the century.

Theoretical questions concerning the nature of animal behavior led to long and vexatious disputes among the philosophers and more speculative naturalists. Condillac in his "Traité des Ani-

maux" (1755) maintained that animals possess a soul; that they have the capacity for sensations and memory, ideas and judgment. They do not arrive at the level of arts, science, morality and religion in their development mainly because their inferior bodily equipment seriously limits their range of experience. He makes no appeal to instinct but emphasizes the factor of experience in the development of specific behavior patterns; in seeking to supply its organic needs the organism builds up its repertoire of movements. The innate factor is thus reduced to the minimum. This point of view was also taken by many naturalists of the time, such as C. G. Leroy in France and Erasmus Darwin in England. Leroy accepts the general view of Condillac and brings together many observations, drawn from his practical experience as keeper of woods and forests to Louis XV, in support of this position in his "Lettres sur l'Intelligence des Animaux" (1764). He ascribed some measure of human feelings, sentiments, and reasoning capacity to animals, although they are not driven to develop these to the highest human level; their feelings are less refined, their reasoning less abstract. In the "Zoonomia" of Erasmus Darwin (2 volumes, 1794) a more extreme anti-instinct attitude is taken. He argues for the essential similarity of animal and human behavior. Walking is a habit set up by experiencing movements before hatching in birds, or *in utero,* in mammals. The human embryo "learns to swallow" as well as to breathe, although the earlier movements in the process are

not always easily determined and are likely to be overlooked. Concerning the social insects, Holmes quotes him as saying:

"If we were better acquainted with the histories of those insects which are formed into societies, as the bees, wasps, and ants, I make no doubt but we should find that their arts and improvements are not so similar and uniform as they now appear to us, but that they arose in the same manner from experience and tradition, as the arts of our own species, though their reasoning is from fewer ideas, and is busied with fewer objects and is exerted with less energy."

Opposition to this general view was voiced by H. S. Reimarus (1694-1768) a German philosopher whose main interest appeared to be the substitution of "natural" for "revealed" religion. He rejected the automaton theory of Descartes, although he also denied that the animal can reason. Infra-human behavior is explained as the result of divinely implanted instincts; in fact nothing, more than the marvellous perfection of instinctive adjustment, gives more conclusive evidence of design in nature. His position is not far from that of Addison, who looked upon instinct as "an immediate impression from the first mover and the divine energy acting in the creatures," and thus inexplicable in terms of physiological principles. His "Triebe der Thiere," which appeared about 1760, was his most important work (c. 500 pages) on animals and was widely circulated. He recognized a large number of

instincts as elaborations of the primary urge of self-preservation and offers a wealth of collected illustrations of "instinctive" activities. Aside from its theological bias the work of Reimarus "smells of the lamp," as Brett remarks in comparing it with that of Leroy.

Darwin and the Anecdotal School.—The announcement of the Darwinian theory (1853) had the effect of greatly stimulating interest in the problems of comparative psychology. As Osborn has shown the notion of evolution had received serious treatment by such naturalists as Buffon and Lamarck and by many philosophers of the preceding century. Nevertheless, orthodox science as well as orthodox theology upheld the doctrine of special creation, and insisted upon the immutability of species, until Darwin's theory by sheer weight of fact replaced the older view. And likewise the mental life of animals was supposed to be summed up in the term "instinct," a mysterious entity constituting the original psychical endowment of a munificent creator. Man was sharply marked off from "the beasts that perish" on the mental side by the faculty of reason which was assumed to be qualitatively distinct from, if not antithetical to, the lower instinctive faculty of the animal. The hypothesis of evolution was quite revolutionary in both biology and psychology. Its fundamental assumption of physical and mental continuity within the organic world, and its serious attempt to account for both along broad genetic lines, led to a deeper and more extensive interest in

animal activities than had hitherto been aroused.

The evolutionary conception, regardless of its specific formulation, brought with it two major problems which were of great importance to comparative psychology. The first, and by far the simplest of these, involved the collecting of evidence to show that the mental life and behavior of all animal forms, from protozoa to man, formed a continuous series; that in passing from the lower to the higher forms no genuinely qualitative differences make their appearance. This was the problem of mental continuity at the descriptive level and, as we shall see, became the central point of interest around which the anecdotal school developed. The second and more serious problem—that of mental evolution—was more or less bound up with the wider problem of the nature of the evolutionary process in general. For certainly both mental and physical development must have come about, in the last analysis, from the operation of the same laws and conditions. An analysis of the factors involved in this process, and the determination of the relative importance of each factor in mental evolution constitutes a problem of such difficulty that a full and satisfactory solution has not as yet been reached.

As before stated, the anecdotal school, which flourished for about three decades following the announcement of Darwin's theory, set itself the task of showing that mental continuity was an indubitable fact. The problem narrowed down pretty much to that of proving that the

higher animals possessed a rudimentary reason from which the intellectual life of man might conceivably have evolved. For traditional theology and science had placed the real gap between man and the higher animals. This group was willing enough to concede mental continuity if only man were left out of the scheme. In fact, the old doctrine of "instincts" was a tacit acknowledgment of such continuity below man. That much of man's behavior was actuated by instincts, not unlike those of the brute, could also be conceded, so long as the primacy of man as the sole reasoning animal was not questioned. But the doctrine of evolution did question this and therefore forced the issue. The need of the hour was for evidence of reasoning and other characteristically human mental life in the higher animals.

The anecdotal school confined their efforts almost wholly to the collection of stories, sometimes of dubious veracity, emphasizing the supposedly rational, emotional and ethical conduct of the higher animals. Among the more conservative representatives of the group may be mentioned Darwin, Lubbock, Brehm and Romanes. One of the most dependable of the later collections is Romanes' "Animal Intelligence" (1883). There were scores of collectors who either wrote or lectured on the marvellous intelligence of the animal world; the tendency to humanize and eulogize often reached the ridiculous, but at any rate the popular imagination was deeply stirred. Appeal was had not only to con-

temporary story-mongers but also to the writings of Pliny, Aristotle and other of the ancients for evidence to serve as a brief that the higher animals were "almost human." Just as philosopher and theologian had twisted the facts in order to create an insuperable gulf between the mental life of man and animal by glorifying the one and degrading the other so now the gulf was not only bridged, but the difference between man and animal unduly minimized by a reversal of the process, due in large part to the temper of the times.

The evidence for a rudimentary human mind in the higher animals centered around the following points, as will appear from an analysis of the vast accumulation of anecdotal material of this period: (1) cleverness of animals in making advantageous use of natural environmental conditions, such as the beaver building its dam at strategic positions, etc.; (2) unusual cases of cleverness, presumably involving reasoning, in domestic or captive animals in their artificial environment; (3) imitation of the actions of man or other animals which might imply rational inference; (4) intercommunication of ideas and plans of action and other social activities which suggest purposive coöperation; (5) emotional reactions which suggest ethical considerations of a rudimentary sort, such as deceit, shame, sense of justice, altruism and the like.

Prominent among the naturalists of the period who opposed the doctrine of mental continuity and held tenaciously to the traditional theologi-

cal view stands Fabre, whose life-long study of the insects remains a marvel of indefatigable labor and detailed observation. He looked upon instinct as a mysterious entity operating as a sort of "inspiration" from above, and having nothing in common with the rational faculty which man alone possesses. Both Fabre and the Jesuit Father Wasmann, who in our own time is a prominent student of insect life, argue for the position of the mediæval church; the primacy of man and especially moral responsibility as then conceived must be upheld at any cost. The evolutionary psychology, by denying the essential difference between the mind of man and animal "not only raises brutes," as Wasmann puts it, "to the dignity of man, but degrades man to the level of the brute," the practical consequence being "the demoralization and brutalization of man."

The crux of the problem concerning the nature of the process of mental evolution and the determination of the actual course of such evolution was to account for the development of specific instincts as patterns of psychic morphology. Intelligence or reason was coming to be looked upon as nothing more than the elaboration of a complex instinctive life, and therefore as presenting no special difficulties. To show how, and under what influences, the typical instinctive patterns had evolved from the simple and more or less undifferentiated response of the primitive life substance, was necessary if the doctrine of mental evolution was to be properly supported.

A half century before Darwin published his theory, Lamarck had attacked the problem, and his solution had been later elaborated by Spencer and designated the "lapsed intelligence theory." Lamarck held, in brief, that use and disuse of parts of the organism brought about more or less definite local changes in the parts which were transmitted from generation to generation. He did not deny the influence of the direct effect of environment (Buffon's principle) but stressed functioning (use and disuse of parts) as the all-important factor, and he included conscious as well as physiological functioning. It is the desire of the giraffe to feed on higher foliage, accompanied by the stretching of the neck (as the expression of that desire) for countless generations, that has brought about the development of the unusually long neck. Instinctive patterns have been developed *pari passu* with morphological change; habitual responses initiated by conscious desire, or some form of psychic urge, have been passed on as a cumulative heritage and finally fixated in the species as instincts. Lamarck's view is obviously meaningless apart from the generally discarded theory of the heritability of acquired morphological and functional changes in the organism.

While Darwin did not deny the operation of other factors, such as those suggested by Buffon and Lamarck, he appealed in the main to his own principle of natural selection to explain the evolution of the instincts and of mental life in general. Functional types like structural types

had been evolved by the gradual accumulation of favorable variations in the struggle of the organism to survive.

"If it can be shown (he says) that instincts do vary ever so little, then I can see no difficulty in natural selection preserving and continually accumulating variations of instinct to any extent profitable. It is thus, I believe, that all the most wonderful and complex instincts have originated."

Whatever may be the final solution of the problem regarding the process of mental evolution, the idea became thoroughly established during the period under review that such evolution was a biological phenomenon, and must be explained by fundamental biological principles. The theological tradition had been definitely discarded.

Summary.—The early part of this period witnessed the passing of the encyclopedic type of natural history; compilation was gradually displaced by original observation within a restricted field. Specialization within the zoölogical field led to the establishment of various subsciences from time to time throughout the period, developing in the main along the line of the progressive analysis of the organism into finer units. Both the structural and functional groups of subsciences tended also to become broadly comparative in the latter part of the period. Taking the period as a whole we may say that the problems of comparative psychology were pretty

largely ignored until the coming of Darwin at the close of the period, although the Cartesian view stirred up considerable discussion. The doctrine of evolution as enunciated by Darwin, however, aroused a genuine interest in the mental life of the animal from the comparative viewpoint. The narrow search for evidence of mental continuity and the controversial nature of the problems raised by evolution stood in the way of the normal development of the science for two or three decades after Darwin. During this time anthropomorphism and speculation went to deplorable lengths, and the anecdotal method was substituted for systematic and unbiased observation. Near the close of the period this state of things was beginning to change for the better under the leadership of such conservatives as Lubbock and others. The doctrine of evolution had been generally accepted and a measure of sanity in interpreting animal behavior had begun to show itself.

CHAPTER V

THE MODERN EXPERIMENTAL MOVEMENT

Introductory.—In a very important sense Darwin may be looked upon as the founder of modern comparative psychology. For it was the theory of evolution as enunciated by Darwin that stimulated the widespread interest in the subject along broadly comparative lines, as we have already noted. The genetic method, moreover, had the effect of revitalizing human psychology, giving rise in time to the new department of child psychology. In psychology as in other fields the evolutionary concept gave unity and meaning to the vast accumulation of disconnected facts and opinions. After Darwin, psychology began to consider itself a division of biology, and gradually biological categories and the methods of experimental science had been replacing the older metaphysical and subjective categories and the arm-chair methods of the philosopher. In brief, psychology, and especially comparative psychology, has been on the way to becoming, both in theory and in fact, a natural science.

However, the modern movement did not take a direction which gave promise of a genuinely systematic working of the field until the beginning of the last decade of the century. So long as its exponents were holding a brief for human-like intelligence in animals, in order to strengthen the position of the doctrine of mental continuity,

normal and healthful development could not be expected. The entire field of biology was dominated more or less during the same period by the controversy concerning the theory of evolution, which had encountered such strong opposition from the traditional science and theology. Animal psychology merely suffered along with the rest. The anecdotal method which had come into prominence and favor as the handmaid of the humanizing tendency, and which was the favorite method of the post-Darwinian writers, properly belonged to the old rather than to the new scientific order. For these and other reasons it appears more correct to consider Jacques Loeb and C. Lloyd Morgan as the founders of the modern movement which properly began about 1890, and to look upon Darwin as a great pioneer and a forerunner. Both of these men threw their influence against the tendency to humanize the behavior of animals which was still widespread at the time above indicated, and was proving a serious menace to scientific development within this field. The publication by Loeb (1890) of his tropism theory was a blow to the current humanizing tendency from which it never recovered. Morgan began pleading for sanity about the same time, insisting that animal behavior should be investigated for its own sake and not merely as so much evidence either for or against the doctrine of mental continuity and evolution. In 1893 he issued a manifesto against the humanizing tendency which has since been known as Morgan's canon. These events were

extremely important and far-reaching, making possible the later developments toward an objective viewpoint and an experimental methodology, which are the two primary characteristics of the new comparative psychology. The contribution of these leaders will be discussed at greater length in the two succeeding sections.

Loeb and the Mechanistic View.—The tropism theory of Loeb as presented in his paper of 1890 was little short of a return to the mechanistic view of Descartes, and came as a severe and fatal shock to the post-Darwinian humanizers. The interest of Loeb in animal psychology had been aroused through his contact with plant physiology. The term tropism had been introduced by the botanist Condolle as early as 1835, and the nature of tropistic reactions in plants was a live one at the time Loeb began writing. It was generally conceded among the botanists that these orienting movements of plants (as well as movements in general) were purely automatic responses to a stimulation and involved no psychic factors whatsoever. Loeb became convinced that the same principle could be applied to similar behavior in animals with equal validity. This meant a denial of consciousness to most of the lower forms whose behavior in his opinion consists largely, if not wholly, of direct tropistic responses. His view was a direct attack upon such contemporary investigators as Lubbock, Bert, and Graber, who were making extensive use of the so-called "preference method," and interpreting the orientation and aggregation of in-

sects and other invertebrates as an expression of conscious choice, a preference based upon the pleasure-pain principle.

The importance of Loeb in this historical connection does not involve the question as to the ultimate truth or falsity of his special theory, either as at first announced or as later elaborated. His bold attempt to analyze the behavior of animals experimentally, and to explain it objectively in the face of the anthropomorphic babblings of the times was little short of heroic; and if Verworn had made a start in the same direction (in 1886, according to Mast) it was Loeb that exploited the idea and turned the tide of interest in animal behavior into modern channels. It was a far cry from the notion of Romanes that the insect flies into the candle flame out of curiosity to the opinion of Loeb that it does so because it cannot do otherwise.

From the work of Loeb, as Brett remarks, "arose a new type of comparative psychology, the mechanistic school of Bethe, Uexküll, Th. Beer and Ziegler; for these writers the higher animals have consciousness, the lower have not." Such a position raises the question as to an adequate criterion of the presence or absence of consciousness, and on this point Loeb may be allowed to speak for the entire group. He held that the "elemental component" of all psychic activity is "the activity of the associative memory." He argues from this that "if an animal can be trained, if it can learn, it possesses associative memory," and therefore mind. "Our

criterion," he says, "puts an end to the metaphysical idea that all matter, and hence the whole animal world, possesses consciousness." Yerkes has pointed out that such a criterion is meaningless in the face of the fact that the capacity to learn is apparently common to all animals. Furthermore Lloyd Morgan also has shown the logical fallacy of supposing that lack of positive proof of the presence of consciousness is adequate ground for asserting its non-existence in a given organism. Even though admitting the possibility of consciousness in higher forms, this group of physiologists insists that physico-chemical process and the resulting objective behavior of the organism form the proper subject matter of comparative psychology. They agree with the later behaviorist school in questioning the validity of inferences concerning the presence and nature of mental states in animals. Likewise they reject the subjective terminology of traditional human psychology in describing the activities of infra-human types. Bethe, Beer and von Uexküll, in a joint paper issued in 1899, propose to eliminate entirely such terms as sensation, sense-organ, memory, learning, etc., from comparative psychology. They would speak of *reception-organ;* of *phono-reception, stibo-reception,* and *photo-reception* rather than of hearing, smell, and sight.

The reaction against the current anthropomorphism, as represented by Loeb and his followers, met much opposition, especially in the more extreme forms like that of Nuel, in which

human behavior was also explained as tropistic response. Claparède, a Swiss educator, holding the doctrine of psycho-physical parallelism, argues that all organisms are conscious and insists that the psychical as well as the physical series of events should be investigated. He criticised the tropism theory in a satirical vein by showing how an observer from another planet might be led to consider typical human activities as tropisms—the disease tropism of the doctor, the corpse-tropism of the undertaker, for example. Forel, the Swiss naturalist, who holds the double-aspect theory, and therefore finds the physical and psychical coextensive (as aspects of a common substance) attacked the view of Bethe that ants, bees, and other insects are mere machines.

"In these animals (he says) it is possible to demonstrate the existence of memory, associations of sensory images, perceptions, attention, habits, simple powers of inference from analogy, the utilization of individual experiences and hence distinct, though feeble, plastic, individual deliberations or adaptations."

In fact, his view is little short of a return to the anthropomorphism of the post-Darwinian school. Other less severe critics of Loeb's general mechanistic position have also appeared. Jennings, for example, from a tremendous amount of experimental work on lower organisms insists that their behavior is less simple than Loeb's theory would seem to require; that their responses are variable to the same stimulus due

to differences in inner physiological state at different times; that instead of being direct and forced, as Loeb supposes, their responses are more often of the "trial and error" type which favors modifiability. G. Bohn, who "opposes both anthropomorphism and the bare acceptance of tropism," according to Brett, describes his position as "ethological," and takes a positivistic attitude limited to the empirical study of animal behavior. The behavioristic school which represents the main line of advance will be discussed in a later section.

McDougall's "hormic theory" is essentially a return to vitalism in opposition to modern mechanistic views and need not be discussed in detail.

Lloyd Morgan and the Conservatives.—Morgan deserves to rank along with Loeb as one of the founders of modern comparative psychology because of his generally acknowledged leadership of the conservative group—those who represent the continuation of the post-Darwinian tradition, in opposition to the radical position of Loeb. His plea for the study of animal psychology without special reference to the all absorbing doctrine of mental evolution had much to do with the later systematic development of the science, and especially so since he stressed the need of carefully observed fact as against anecdote and arm-chair discussion. The canon of Morgan, which appeared in his "Introduction to Comparative Psychology" (1895) was an attack

against the prevailing anthropomorphism and runs as follows:

"In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale."

The canon is merely the law of parsimony applied to animal psychology; it is an insistence that the same critical attitude which had long been accepted in the methodology of general science be also adhered to in this field. Even the conservatives could hardly reject a principle so fundamental and reasonable, and the influence of this canon on the later development of the science can scarcely be overestimated. For though it did not rule out entirely the fallacious practice of attempting to infer the subjective life of the organism by anthropomorphic analogy, it did serve to introduce a measure of restraint into such speculation.

The practical application of Morgan's canon naturally demanded that a hierarchy of psychical faculties be agreed upon and that objective criteria for each of these faculties be determined. Morgan posits three levels of mental activity, the lowest of which (sentience) he thinks is most likely possessed by all animals. Sentience is, for him, a vague conscious state somewhat analogous to the simple affective states in man. The cognitive faculty is more prominent in the second level (effective consciousness) which is indicated by

the ability to profit by experience; the third level (self-consciousness) implies a still more analytical cognitive state.

More recently Yerkes (1905), in dealing with the same general problem, recognized three levels of mental activity corresponding roughly to those of Morgan: the discriminative, the intelligent, and the rational. He offered, in addition, the following set of objective criteria as a basis for determining the approximate psychic level of an organism:

I. *Structural Criteria*

1. General form of organism. (Organization.)
2. Nervous system. (Neural-organization.)
3. Specialization in the nervous system. (Neural-specialization.)

II. *Functional Criteria*

1. General form of reaction. (Discrimination.)
2. Modifiability of reaction. (Docility.)
3. Variableness of reaction. (Initiative.)

The above criteria are given in the general order of increasing importance, as diagnostic signs of psychic life, functional signs being of more importance than structural, and the particular sign within each group of more value than the general, although, as Yerkes admits, this may not hold in every instance.

In illustrating the application of the criteria, Yerkes examines the evidence for the sea-anemone and concludes that it shows no certain signs of

either intelligent or rational consciousness, and probably possesses a psychic life on the lowest level, the discriminative. He questions whether it is not reasonable to suppose, on the basis of such criteria, that the ant possesses a form of consciousness which is comparable in complexity of aspect and change with the human.

In the same year Lukas proposed that in addition to morphological and physiological criteria of the presence and nature of consciousness, a third general type, the teleological, should be added to take account of the possible significance to the organism of apparently conscious, purposive activity.[6] The zoölogists, insofar as they deal with the problem at all, are in the main inclined to follow Loeb and take the capacity to form associations as a working criterion of the presence of consciousness.

The inadequacy of these and other objective criteria of the psychic has been pointed out by Washburn who fittingly recognizes the insuperable difficulties involved. There are no qualitative distinctions either on the structural or the functional side that are known to be certainly correlated with particular levels of subjective experience. If psychic life arises when structure reaches a given degree of complexity, then indeed, how may we determine the crucial stage? And since all organisms show some degree of modifiability of behavior (which is, perhaps, the most

[6] See also McDougall's "Hormic Theory" and his criteria of "purposive behavior." "Outline of Psychology," Chapter II.

valid functional criterion) then how may we differentiate between conscious and unconscious modification of behavior? Speed of learning will not do, since it has no positive value unless the speed is such that "memory ideas" must be assumed, and this would "conflict with the evidence from structure" by ruling out the certainty of consciousness in highly complex forms in which the evidence for such ideas is inconclusive. Finally Washburn, while insisting upon the validity of inferences as to the subjective state of the organism, frankly admits that the qualitative aspect of such states cannot be inferred with any degree of probability, especially in species markedly different from man in structure.

Thorndike, and the Laboratory Method.— One of the distinguishing marks of the modern movement has been its attempt to substitute experimental control for loose, inadequate observation and other uncritical methods. The first move in this direction was the repudiation of the so-called anecdotal method which was in such high favor in the period immediately following Darwin. The chief criticisms that may be urged against this method are: (1) that the observer is likely to be untrained and unable to give an accurate account of the happening, even if his intentions are of the best; (2) that interpretative elements are likely to be confused in the report with factual, making it impossible for the scientist later to separate the two; (3) that the happening even when adequately reported is

usually an incident cut off from the essential genetic antecedents (both individual and racial) which would explain it and give it proper significance; (4) that the happening, in the nature of the case, represents highly selected and atypical behavior that can have little or no statistical validity; (5) that even if the tendency of mankind to humanize the animal—whether in a scientific or a literary mood—is restrained, errors of memory and of transmission (if verbal) are likely to enter; and (6) there is the difficulty of selecting reliable, authentic material from the various available sources. The method even when guardedly employed, which usually is not the case, hardly deserves to be considered scientific. It properly belonged to the previous period and passed out with it.

It is not easy to say when experimental methods first began to be employed in comparative psychology, inasmuch as the matter finally reduces to a definition of the term experimental. Naturalists from the time of Aristotle onward have utilized simple controls in connection with field observation. Faber, Lubbock, Morgan and others of their day arranged unusual and artificial conditions, both indoors and in the field, with special reference to some question in which ordinary observation did not afford a final answer. In most cases a simple control of the conditions of stimulation was introduced without any attempt being made to control the movements of the animal. In his study of insects,

however, Lubbock [7] developed apparatus that appears quite modern in its control of both stimulus and organism. Much of the work of Verworn, Loeb, and Morgan was experimental in a broad sense. And Galton's study of the auditory range of animals in the zoölogical gardens of London (1883) by means of a whistle concealed in his hand deserves likewise to be so classed. Experiment grows quite naturally out of critical field observation, and the two can hardly be distinguished. Simple experiment in the field passes gradually over into the more complex and rigorous test and training methods of the laboratory; for the laboratory is, after all, only a limited and controllable field.

Thorndike, however, deserves the credit for having introduced the modern laboratory type of experiment into comparative psychology. His pioneer studies on learning and imitation in chicks, cats, dogs and monkeys began to appear in 1898. These ingenious experiments drew attention to the large possibilities in laboratory control, and they remain classic examples of methodology in this field. Almost immediately laboratories were established at Clark, Harvard, and Chicago Universities, and research on a smaller scale undertaken at many other institutions. At the present time there are 23 laboratories in the United States actively engaged in research, while animal experiments are carried

[7] Note, for example, the rotating table devised for him by Francis Galton; also the wooden bridge and the paper pathways—all described in "Ants, Bees and Wasps," Chapter IX.

out in connection with the general psychological laboratory in almost as many instances. Special courses of instruction (usually with laboratory work) are also offered in 39 American colleges and universities. It is not too much to say that the leadership of America in comparative psychology is very largely due to this extensive development of the laboratory method during the past three decades.[8] Thorndike, Yerkes, Watson and Carr stand apart as the most important early leaders in the movement.

Thorndike's initial work was an innovation and called out criticism from various quarters. Among others Wesley Mills, professor of physiology at McGill University, who has made extensive observations of animal behavior, attacked the work. The chief objections raised were: (1) that the artificial laboratory situation and the arbitrary problems presented made a fair test of the animal's ability impossible; (2) that the study of "normal" behavior was ruled out by the same token, and especially so when punishment was introduced as a motivating stimulus (Thorndike's report that his animals were reduced to "utter hunger" in some cases was evidently misunderstood). Burroughs and others criticised the general method on sentimental grounds. The

[8] In 1911 the "Journal of Animal Behavior" was established, together with the "Behavior Monographs." Both were suspended in 1917 on account of war conditions. In 1921 the "Journal of Comparative Psychology" (with Monograph series) was established as a continuation of the older journal and of "Psychobiology," two volumes of which were issued between 1917 and 1921.

defense of the experimentalists was that a serious attempt to keep conditions in the laboratory as nearly normal as possible was usually made; that problems were selected with reference to the apparent capabilities of the organism rather than altogether arbitrarily; that animals probably suffered less even under the so-called "utter hunger" of the laboratory than in a state of nature. The opposition died down as the true nature of the work became better understood.

It would be a mistake to suppose that the modern experimental movement in this field should be credited wholly to the efforts of the psychologists. Many of the most important contributions have been made by physiologists and zoölogists as will appear when we come to survey the content of the science. In the latter group Jennings deserves special mention on account of his pioneer work on the modifiability of lower organisms, which began to appear about 1902. Jennings gave currency to the notion of "trial and error" behavior, and he and his students have worked untiringly to reveal the nature of behavior in simple organisms. The physiologist Loeb also worked upon the same problem as we have noted. The Russian physiologist, Pawlow, more recently originated the method of the conditioned reflex, which has become one of the standard methods in the animal laboratory. Contributions to the science are constantly being made by many workers in the various branches of biology, but even a general account of these cannot be given here.

Watson and the Behaviorists.—The development of methodology as sketched in the preceding section—from the casual observation and anecdote of a half century ago to the critical field work and laboratory control of today—was accompanied by a corresponding advance along general theoretical lines. As we have noted, the modern movement was ushered in by the revolt against sentimentalism and subjectivism in interpretation, under the leadership of Loeb and Lloyd Morgan. But neither these men, nor their immediate followers, adopted a thoroughly consistent objective viewpoint, such as was necessary to raise comparative psychology to the dignity of a genuine natural science.

Morgan, as the leader of the conservatives, did not deny the validity of anthropomorphic interpretation, but merely insisted that a critical rather than a sentimental attitude be maintained in making inferences concerning the subjective life of animals. The radicalism of Loeb did not lead him to reject subjective interpretation insofar as the higher animals are concerned. He and his school accepted one of the current views of the day which maintained that at some critical point in the phyletic scale the psychic factor, as something *sui generis,* entered. When present this factor furnished subjective data with which the comparative psychologist could and should deal. Organisms below this critical point in the scale were mere automata in the Cartesian sense, and here physiological activities and objective behavior must constitute the proper data of psy-

chological description. The radicalism of the objective physiologists consisted in placing the critical point, at which the psychic factor enters, high in the scale as a rebuke to the current tendencies toward pan-psychism. Their view involved a metaphysical dualism, implicit or explicit, of the Cartesian variety and hence was conservative enough insofar as its metaphysical premises were concerned. It left the comparative psychologist with such speculative problems on his hands as the determination of the critical point (in both phylogeny and ontogeny) when consciousness enters, and the selection of adequate criteria of the psychic to be used in anthropomorphic analogy. The radicals and the conservatives did not differ essentially, except that the latter were less critical than the former, and more liberal in their interpretation of the mind of lower animals. Neither group had been able to throw off entirely the yoke of metaphysical tradition and consider the organism as an object of natural science in the broad sense. Anthropomorphism was still the "bogey" in animal psychology, as it had once been in the field of natural phenomena before the development of physico-chemical concepts.

It remained for Watson (from about 1912 and onward) to bring to comparative psychology a straightforward and consistent objective viewpoint. Watson denied that the psychologist, as scientist, had any right to recognize such philosophical distinctions as mind-body, subjective-objective, conscious-unconscious. To the em-

pirical observer there exists only the organism as an object and its movements, or behavior, and these constitute the sole data of a scientific comparative psychology. Such subjective categories as sensation, emotion, image, etc. (as currently conceived), are logical artifacts rather than entities, or processes discoverable by natural science methods. They are meaningless to the scientist, therefore, however valuable they may be to the philosopher. The living organism presents no mind-body dichotomy to the biological observer but is, for him, a unitary object in the same sense that an atom, a molecule, or a boulder is such for the physical scientist. Speculative analysis and interpretation, insofar as they are justified at all, belong to the philosopher; the psychologist must use a descriptive terminology that properly belongs to the scientific universe of discourse. He cannot juggle into his system subjective categories about which natural science can know nothing.

This view eliminates from comparative psychology all anthropomorphism. Both the older schools were agreed that interpretative inference as to the psychic life of animals was likely to be dangerously speculative; Watson and the behaviorists went the logical limit by insisting that the speculative element was so large as to render such inferences worthless. The problem of the critical point at which the psychic enters, and of the criteria of the psychic obviously does not arise in an objective system. Watson applied this principle to man as well as to infra-human or-

ganisms, denied the validity of introspection as a psychological method, even when inferences based thereon are not carried beyond the human species. We are not here concerned, however, with his attack upon subjectivism in human psychology, which amounts to an attempt to cast out egocentric interpretation from human psychology just as anthropomorphism was being forced out of the infra-human field by the objective principle. It should be clear, however, that only objective data on the human animal can be utilized in a comparative psychology which is broad enough to include the human species. So far, then, as comparative psychology is concerned, the behaviorist argument must carry with reference to man, as well as lower forms. For, since man is the only animal to which the introspective method applies, subjective categories and data must at best be limited to the human and only so much of human psychology as can be stated in objective categories can be considered as comparative data.

The behavioristic position represents the complete overthrow of metaphysical speculation in comparative psychology and the substitution therefor of biological conceptions and methods. Its major categories are organism, stimulus, and response or behavior. These represent, in each case, objective phenomena which can be reduced, theoretically at least, to the quantitative terminology of natural science (C. G. S. units). The determination of the laws of stimulation-response as involving a process of interaction between the

organism and its environment becomes the proper goal of this objective comparative psychology.

Summary.—The modern movement under the leadership of Loeb and Lloyd Morgan began as a revolt against the post-Darwinian anecdotal school. Two parallel lines of development may be distinguished during the period—the one methodological and the other theoretical in nature. The introduction of experimental methods, and especially the laboratory type of control by Thorndike, has made possible the gathering of more exact and quantitative data in this field. This is especially true in America where experimental technique is widely used and is being continually improved and extended. The theoretical advance, led by Watson and the behaviorists, is marked by the overthrow of metaphysical speculation and anthropomorphic interpretation in comparative psychology. A biological or organismic viewpoint has come to be the prevailing one with its insistence on objective, quantitative data.

THE END

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